WATER, BEHAVIOR, AND HEALTH IN ALASKA

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Abstract

This dissertation addresses the need for a better understanding of how water and sanitation infrastructure and water use behaviors come together to influence health. The ultimate aim is to inform water infrastructure designs and behavior change programming for the prevention of acute respiratory infections (ARIs), skin infections, and diarrhea. All three diseases are of public health significance in Alaska, and all three can be prevented by proper access and use of water and sanitation services. I begin the dissertation by illustrating that some residents who have access to treated water continue to consume untreated river water and rain. In fact, 82% of respondents (n=172) reported that some of their drinking water came from an untreated source. Motives for drinking untreated water could be categorized into six themes: chemicals, taste, health, access, tradition, and cost. The next chapter describes the design and impact of a health promotion program to increase consumption of treated water. Self-reported data revealed that from pre- to post-intervention, the proportion of households drinking mostly treated water increased by 21% (39% to 60%), $p < 0.0001$. The third chapter reports changes in water use and health as reported by participants who recently received modern sanitation services. Most participants (n=101; 74%) reported improved community health. A prominent theme was that better access to treated water increased children's ability to drink treated water and perform hand washing and bathing, practices known to prevent ARIs, skin infections and diarrhea. Based on the findings, I recommend: 1) providing in-house piped water service where feasible, 2) development of an alternative water and sanitation system that provides adequate quantities of water for homes that may not be

provided in-house piped water service, and 3) providing health promotion to encourage healthy water use, either in combination with provision of in-house water service, or as a stand-alone intervention.

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Acknowledgement

I would like to thank Captain (CAPT) Jeffrey Smith of the U.S. Public Health Service and the Alaska Native Tribal Health Consortium. CAPT Smith has served as my professional mentor since 1999 and my direct supervisor since 2003. Without his encouragement my journey to the PhD would not have begun. Without his support, patience and wisdom the journey would not have been completed.

Chapter 1: Introduction

This dissertation addresses the need for a better understanding of how water and sanitation infrastructure and water use behaviors come together to influence health. The ultimate aim is to inform water infrastructure designs and behavior change programming for the prevention of acute respiratory infections (ARIs), diarrhea and skin infections in rural Alaska. All three diseases are of public health significance to Alaska Native people (1-4), the primary inhabitants of rural Alaska. These health outcomes are attributable to inadequate water and sanitation and can be prevented by availability of modern water and sanitation infrastructure (1, 5, 6, 7).

There are three components of a modern water and sanitation system. The first is making treated water available for drinking. This step is necessary to prevent diseases caused by consuming untreated water containing pathogens. Diseases caused by ingesting untreated water have been termed “water-borne” (8). Diarrhea is a common waterborne disease (9). The second component of a modern sanitation system is mechanically piping water from the point of treatment to the consumer. Providing an abundant and convenient supply of water in the home leads to more frequent hand washing and other domestic hygiene practices (10, 11), practices known to prevent ARIs, diarrhea and skin infections (7,12, 13,14, 15, 16, 17). Diseases prevented by domestic hygiene practices have been termed “water-washed” (8). In the context of water, ARIs and skin infections are only known to be water-washed (8), while diarrhea can be either water-washed or water-borne (8). The third component of a modern water and sanitation system is availability of a

flush toilet. Safe sewage disposal reduces the potential for spread of pathogens that may cause diarrhea via water-borne or water-washed pathways (5, 6).

Unfortunately, not all rural Alaskans have complete modern water and sanitation services. Even though essentially all of these residents have access to treated drinking water, in many instances the water is not piped to the home but instead must be carried from a centralized water distribution point known as a "water point". This primitive method of water distribution is commonly known as "self-haul". Self-haul is time-consuming and labor intensive, and limits the amount of water available for domestic hygiene practices (18), practices that are necessary for prevention of water-washed diseases. While no previous studies have provided data on water use or domestic hygiene practices in Alaska, several ecological studies have linked self-haul water distribution with increased risk of ARIs and skin infections (1, 19, 20). Consumers who must self-haul water typically dispose of sewage in a 5-gallon bucket known as a "honeybucket". While the health implications of honeybuckets in Alaska are not well documented in the literature, outbreaks and epidemics of sewage-related disease have been attributed to this primitive sewage disposal method. Finally, many communities where most households lack modern water and sanitation service have a "washeteria". A washeteria is a community facility where residents who lack pressurized water in the home can shower and wash and dry their clothes. The water point is typically co-located with the washeteria.

This dissertation was written during a period of transition for Alaskan water and sanitation programs. After more than 50 years of effort and billions invested, there are still an estimated 4,500 to 6,500 rural Alaskan households served by only self-haul and honeybuckets (Source – presentation by Bill Griffith on 4/28/2014). The difficulty and expense of "putting the honeybucket in the museum" has led individuals managing Alaskan water and sanitation construction programs to the realization that all households cannot be provided modern water and sanitation services. As such, efforts are underway to develop alternatives to the traditional modern water and sanitation system that provides an acceptable level of protection against water borne and water washed diseases (Source – presentation by Bill Griffith on 4/28/2014). This effort is being led by the State of Alaska and is named the Alaska Water and Sewer Challenge (Source – presentation by Bill Griffith on 4/28/2014).

While Alaskan programs recognize the need for an alternative water and sanitation system design, there is also growing recognition that providing infrastructure alone is not enough to prevent disease (21). Water and sanitation infrastructure is useless if used improperly or not at all (22). When Alaskan water and sanitation programs began providing infrastructure in 1960, it was assumed that residents would passively adapt to the new technology. The assumption has proven incorrect, as many residents, regardless of water distribution method, continue to drink untreated river water and rain, and ration water to a level that ability to perform domestic hygiene measures is compromised (18, 23). To maximize health benefits of the infrastructure, there is a need to better understand water use practices of rural Alaskans, the motives for performing unsafe practices and

effective techniques for encouraging healthier practices. Health promotion is the art and science of helping people change their lifestyle toward a state of optimum health (24). Health promotion programming has been effectively used to help populations adapt to new water and sanitation technologies (25). Any alternative water and sanitation system that arises from the Alaskan Water Challenge will need to be installed in conjunction with health promotion programming to ensure proper and adequate use.

This research was conducted in four Southwest village communities where the vast majority of residents identified with Alaska Native heritage. Most homes in the four villages were scheduled to transition from self-hauled water distribution and honeybucket sewage disposal to piped water and flush toilets during 2009. It was thought that installation of modern services would provide a unique opportunity to better understand how water and sanitation infrastructure and water use behaviors come together to influence health. My approach relied heavily on qualitative research methods. A key distinction between qualitative and quantitative research is the types of data they use. Qualitative research uses words as data while quantitative research uses numbers as data (26). My reasons for employing qualitative methods are two-fold. The first is that, because qualitative methods use words as data, they are more capable of producing the rich details that are needed to inform the "who, what, when, where and how" of Alaskan water and sanitation issues (27). The second reason qualitative methods were employed is that most previous studies on the topic used quantitative methods and it was thought that studies using qualitative methods would complement the existing body of research. The

following paragraphs provide a brief overview of the three research topics that comprise the dissertation.

I began this dissertation by demonstrating that consuming untreated river water and collected rain is a common practice among consumers with self-hauled water distribution (Chapter 1). In this informative qualitative study, six motives for consuming untreated water when treated water is available were described. I then provide recommendations for a behavior change program to increase the proportion of households consuming treated water in the four village communities. Recommendations for change were based on a social ecological model with four levels of influence: the individual, and the social, built and policy environments. While the primary focus of this chapter was the drinking water source preferences of households in four village communities in Alaska, I also provided broader guidance for the field of environmental health, suggesting that informative qualitative methods should be used to a greater extent and that the social ecological framework is an ideal model for behavior change interventions in environmental health because of how it acknowledges and applies the role of the environment in shaping individual behavior.

Chapter 2 describes the development, implementation and impact of a behavior change program aimed at increasing consumption of (only) treated water among households in these communities. The intervention was named Project Meq-Egtaq (meaning nice water) by local residents. Educational activities carried out under Project Meq-Egtaq were informed by the aforementioned qualitative study (Chapter 1) in addition

to insights gleaned from informal discussions and observations made while administering the in-person survey. Households represented three water delivery scenarios that corresponded to when (or if) they were provided piped water service. Education was offered to all households in the four communities, regardless of which of the three water delivery scenarios they represent. Data were analyzed and recommendations were provided in accordance with the water delivery method available to the home. These represent three different public health applications for future behavior change efforts. In addition to recommendations for future behavior change programming on the topic of consuming treated water in Alaska, I advocate for increased use of behavior change through education within the profession of environmental health.

Finally, Chapter 3 is focused on households that received piped water delivery and education during the research period. I describe how the changes in water use and water use practices following the dual-pronged intervention led to significantly lower rates of acute respiratory infections, as well as diarrhea (as confirmed by a companion study completed as part of the larger program of research). I also provide recommendations to inform the development of alternative water and sewer systems in Alaska that cannot be provided piped water and flush toilets in the near term due to economic and engineering limitations.

A better understanding of how water service infrastructure and water use behaviors come together to influence health is needed to inform future behavior change

programming and water infrastructure designs for the prevention of acute respiratory infections, diarrhea and skin infections in Alaska.

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Chapter 2: Consuming Untreated Water in Four Southwestern Alaska Native Communities: Reasons Revealed and Recommendations for Change[1]

Abstract

We provide the first in-depth account of why some Alaska Native people drink untreated water when treated water is available. Our qualitative research was conducted in four Alaska Native village communities that have treated water available from a centralized distribution point. Motives for drinking untreated water were elicited during in-person surveys completed with a respondent from 210 of 250 eligible households. Most respondents (n=172; 82%) reported that some of their household's drinking water came from an untreated source. Motives for drinking untreated water emerged from analysis of open-ended questions about drinking water practice, and could be categorized into six themes: chemicals, taste, health, access, tradition and cost. Some residents freely chose to drink untreated water, while others did so out of necessity brought about by physical and economic limitations. Importantly, some residents reported consuming untreated water because they both liked untreated water and disliked treated water. As such, interventions to increase safe water consumption should address these attitudes by providing education about the benefits of treated water alongside the risks involved with drinking untreated water. Based on the findings, we provide specific recommendations for developing behavior change interventions that address influences at multiple social-ecological levels.

[1] Ritter, T., Lopez, E., Goldberger, R., Dobson, J., Hickel, K., Smith, J., Johnson, R., & Bersamin, A. (In press). Consuming untreated water in four southwestern Alaska Native communities: Reasons revealed and recommendations for change. Journal of Environmental Health.

Introduction

Drinking contaminated water is a well-documented risk factor for infectious disease. Currently, more than half of the hospital beds in the world are occupied by persons affected by inadequate water supply and sanitation (1). While the highest burden of water-related disease is found in developing countries, unsafe water consumption continues to affect U.S. populations (2). Waterborne diseases cost the U.S. healthcare system an estimated $900 million each year (3).

The treatment of drinking water is an important preventive measure for waterborne disease. Water treatment is the purification of water to make it suitable for drinking or other domestic use. Most major U.S. cities began providing treated drinking water in the early 1900s. This increased availability of treated water in the U.S. contributed to the dramatic decline in the crude death rate from infectious disease that occurred during the first part of the twentieth century (4). Construction of water treatment systems in Alaska Native communities, however, did not begin until the 1960s.

Water system construction in Alaska's Native village communities falls under the jurisdiction of either the Alaska Native Tribal Health Consortium, a not-for-profit tribal organization that provides water, sanitation and health services to Alaska Native people and communities across the state (See ANTHC website http://anthctoday.org/about/index.html for more information), or the State of Alaska's Village Safe Water program. Funding for water infrastructure in rural Alaska is limited and communities must demonstrate strong support and capacity for their proposed

projects to be funded. Once in place, ownership and operation of the infrastructure is transferred to a governing entity within the community, typically the tribal or city council. Sustainability can be a challenge. Local communities take on responsibility for daily operation and maintenance with training and limited on-site technical assistance provided through external programs. Revenue to pay for water system operation and maintenance is generated through user fees, but this does not always cover costs. Most village water utilities have no formal process for receiving and resolving consumer complaints or for educating consumers about water safety.

Currently, almost all residents of Alaska Native villages have access to treated drinking water. Yet for about one in four rural residents, treated water must be packed, or "self-hauled," to their homes from a centralized water point. Self-haul water systems require residents to fill and carry several small containers of water from a central water point to their homes using sleds, snow machines, or four wheelers.

Despite the availability of treated drinking water in Alaska Native communities, it is widely recognized that many residents drink untreated water. This is of particular concern because microbiological sampling of untreated water found numerous pathogens, including *E. coli*, *Cryptosporidium* and *Campylobacter*, and that rooftop-harvested rainwater contained *E. coli* (ANTHC & CDC, unpublished data, 2010). Two studies provide insight on why Alaska Native people with access to treated water continue to drink untreated water (5, 6). One study conducted in Alaska's Northwest Arctic region found that residents associated chlorine in treated water with the onset of cancer (5). A

2009 study by Marino et al. revealed that residents in two Norton Sound region villages preferred the taste of untreated water to treated water and that they believed their untreated sources were superior in terms of health and safety. Study participants were wary of chemicals used in the water treatment process and preferred untreated water because they regarded it to be "more natural."

Our study builds on the previous research in three ways. First, we use thematic analysis to identify and analyze participant-reported motives for drinking untreated water and describe the interconnections among them. Second, based on our analysis, we provide recommendations for encouraging consumption of only treated water. Third, our research was conducted in Alaska's Southwest region, exploring perspectives that may differ from those found in previous studies in Northwest Alaska, where residents may espouse different cultural and health-related values.

Methods

Setting

We conducted our research in four small, remote Southwest Alaska village communities. Each community was selected because of their participation in a larger study exploring the impact of inadequate water and sanitation on rates of infections. In 2010, the combined population was 1,403, with the vast majority of residents (93.9%) identifying with Alaska Native heritage (7). These village communities ranked among the most remote in Alaska. With no external road system, access between communities and urban centers is possible only by small airplane, snow machine, and the occasional

summer barge. The selected communities also experience extreme weather conditions, with winter temperatures dropping to -40 degrees Fahrenheit. Subsistence activities, such as hunting, fishing, and gathering (berries and greens), hold cultural, social, and economic significance to these communities, where employment opportunities are limited and more than 40% of residents over age 16 are not in the formal workforce (7).

Participant Eligibility and Recruitment

The study materials and processes were approved by the Alaska Area Institutional Review Board, the Human Subjects Review Committee of the regional tribal health consortium, and the four representative village councils. The research focused on the estimated 250 households with only self-haul water distribution. Recruitment comprised announcements made over VHF radio (a simple transmitting device used as a primary method of communication in this region), recruitment flyers, and other word-of-mouth methods.

Data Collection and Questions

The data presented here were collected as part of a larger semi-structured, in-person survey focused on assessing the change in health status following provision of in-house piped water and healthy water use promotion. In some cases, residents heard the VHF announcements and traveled to a community building to complete the survey. A majority of the surveys, however, were conducted in respondents' homes. To facilitate this, a paid village resident field worker accompanied a research team member on visits to each eligible household. A total of 8 researchers and 5 field workers participated in

data collection. Surveys were primarily conducted in English. For participants who preferred to use their local language, Yup'ik, the field worker helped to translate questions and responses. Because our previous experience working in this region indicated that the presence of a tape recorder often negatively impacted participation and the quality of responses, surveys were not audio-recorded. Instead, the researcher strived to transcribe participants' responses to the open-ended questions as they were provided. Each household chose one member to complete the survey, and was offered $40 in compensation for the time.

The survey interview opened with the question, "How much of your household's drinking water comes from the (treated) water point?" Response options included "none," "some," "most," and "all." Participants who chose responses other than "all" were asked to elaborate by explaining their motives for consuming untreated drinking water. Data collected from this series of questions are the focus of this report.

Data Management and Analysis

Interview responses (both closed- and open-ended) were transcribed into an Excel spreadsheet. Qualitative data were analyzed using a four-phase process. Phase I involved having six individuals trained in environmental health review all of the transcribed statements from the open-ended survey questions. Two of these individuals had also been involved in data collection. They were asked to identify themes related to respondents' reported motives for drinking untreated water. The reviewers collectively identified six motive themes. During Phase II, two researchers who had participated in Phase I worked

collaboratively to develop a codebook that included the six motive themes and their operational definitions. During Phase III, the same two researchers independently coded each response to one or more of the six motive themes. Finally, during Phase IV, the researchers compared their coding and discussed any coding disagreements. This process resulted in inter-coder agreement on 230 of 234 code assignments (98.3%). In the four instances where agreement was not achieved, data for the entire household were excluded from the data set.

Findings

Sample Characteristics

Of the 250 eligible households, 210 (84%) completed the questions relevant to this report. Participating households comprised an average of 3.9 occupants (range = 1-10). Sixty percent of the surveys (n = 126) were completed by a male household member. The average age of the respondent was 48 years (range = 19-83).

Proportion of Drinking Water Obtained From an Untreated Source

A majority of participants (82%; n=172) reported that at least some proportion of their household's drinking water came from an untreated source. Untreated sources included river and rain water. The highest percentage of participants (39%; n=82) reported their household obtained "none" of their drinking water from the water point while the lowest percentage (18%; n=38) reported that "all" their drinking water came from the water point (Figure 2.1).

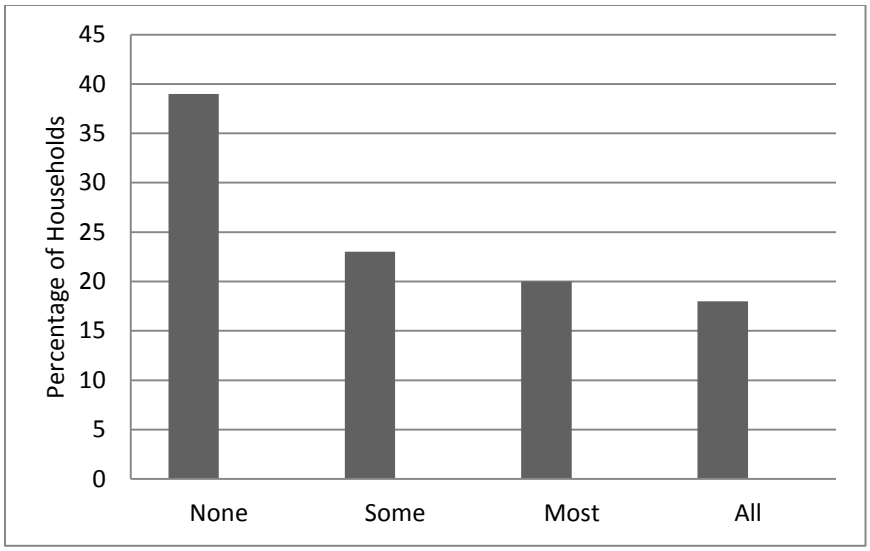

Figure 2.1: Reported Proportion of Drinking Water from the Treated Source, Alaska (n=210)

Motives for Drinking Untreated Water

Of the 172 participants reporting that any of their household's drinking water came from an untreated source, 153 (90%) answered the open-ended question to explain their motives for drinking untreated water. Data from four households were excluded during the coding process, leaving 149 respondents. Respondents offered multiple reasons for drinking untreated water, with a total of 204 separate explanations provided. The six identified motive themes include Chemicals, Taste, Health, Access to Water, Tradition, and Cost; these are discussed in detail below. Table 2.1 provides the number and percent of households reporting each of the six motive themes along with illustrative quotations.

Table 2.1: Motives for Drinking Untreated Water When Treated Water is Available, Alaska, 2008

Motives (No. and percent of households reporting motive)	Illustrative Participant Quotations
Chemicals (n=69; 46%)	"If pump water has too much chlorine we go to the creek." "We don't like chemical water." "I don't like chlorine." "I don't trust the chlorine that much."
Taste (n=67; 45%)	"Chlorine doesn't go good with coffee. Creek water tastes sweeter." "Sometimes water at the water point tastes too much like chlorine." "Sometimes [treated water] tastes like rust." "[Untreated water] doesn't have a taste like slimy treated water."
Health (n=40; 27%)	"River water builds immunity." "Too much [treated water] will kill anybody." "Treated water has chlorine and fluoride so it might have side effects." "Chlorine makes my dad sick in his stomach."
Access (n=25; 17%)	"No transportation to haul [treated] water." "[Rain] is right outside." "Water points are too far from home." "Rain falls from the sky to my bucket."
Tradition (n=13; 9%)	"I grew up with river water." "That's what we've always had." "I've never tried treated water." "That's how we were born and raised."
Cost (n=12; 8%)* (n=12; 18%)**	"You have to have money to buy treated water." "Can't afford [treated water]." "Water from the river is free." "[Drinking rain] saves money."

* Includes all households (n=149).

** Includes only households in two villages where there was a charge for water (n=65).

Chemicals

The use of chemicals in the water treatment process was the most common reason provided for choosing to consume untreated water (Table 2.1). Most respondents who expressed concerns about chemicals specifically named chlorine as the source of their opposition. Respondents explained that people disliked the taste and smell of chlorinated water, were concerned about the potential negative health effects caused by chlorine, and viewed chemical water treatment as a western practice that conflicted with the widely held preference for things produced naturally. Some respondents associated chlorine taste and smell with poor water treatment system operation and maintenance. Even though fluoride is not added to the treated water in any of the four villages, a few participants expressed concern that fluoride in their treated water may produce negative side effects.

Taste

Many respondents explained that they simply disliked the taste of treated water. According to participants, treated water tasted "weird," "salty," "yucky," and even "slimy." The themes Taste and Chemicals overlapped substantially, with 31 of the 67 respondents (46%) reporting both as reasons for consuming untreated water. Most respondents who mentioned taste emphasized their dislike of chlorine. Six respondents specifically noted that "chlorine doesn't go good with coffee," an observation also made in Marino's study (6). Respondents also characterized treated water as unpalatable due to high iron content, which gives the water a rusty taste. Dislike of the taste of treated water was not the only taste-related motive, however. Many respondents explained that they

enjoyed the taste of untreated rain and river water, describing it as “crisp,” “clean,” “sweet,” and “fresh.”

Health

Health emerged as a motive for consuming untreated water. While a few respondents believed that untreated water offered health benefits, more than a quarter of respondents, or 40 of 153, associated treated water with health problems such as stomachaches, diarrhea, headaches, allergic reactions, dry skin, and even death. Most common were concerns regarding gastrointestinal problems experienced by young children, older residents, and honored Elders. Of the 40 respondents who mentioned health as a motivator, 18 (45%) also discussed their negative opinions of chemicals, so there was frequent overlap in the first three categories. Chlorine was the chemical that participants most commonly associated with their health concerns. Respondents also associated the yellow, brown, and rust color that often results from high iron content in treated water with health problems, even though ingesting iron at levels found in drinking water is not a known health risk.

Concerns related to improper or inadequate water system operation and maintenance influenced participants’ drinking water choices. Several participants blamed faulty operation and maintenance for the taste and smell of chlorine, the color associated with iron in their treated water, and the potential for health problems. As one respondent stated, “I’ve seen the water tank. I think it needs to be cleaned.”

Access to Water

Self-hauling treated water from the water point, a difficult and time-consuming process, was described as a barrier to consuming treated water when untreated water could be obtained in closer proximity to the residence. Respondents noted that rainwater was particularly accessible because it could be harvested on-site with no need for packing and hauling. Lack of transportation to haul treated water was reported as another barrier. In addition, having to obtain tokens for the coin-operated water points was described as a "hassle" that further deterred treated water consumption.

Not surprisingly, accessing treated water was a barrier for residents with physical- or age-related limitations. One older respondent offered that she drank treated water in the winter and rainwater in the summer. When asked to elaborate, she explained that her son hauled treated water for her in the winter, but during summer he was away from the village at fish camp, leaving her to consume the more easily obtained rainwater. A respondent living with paraplegia described a similar reliance on others to fetch his water.

Tradition

Treated drinking water became available in the four villages in 1962, 1968, 1981, and 1985. Until then, residents had no choice but to consume untreated water. Many respondents described consuming untreated water as the social norm. In fact, a few participants admitted that they had never even tried the treated water available to them. Those who attributed their use of untreated water to tradition tended to be older (average age = 55 years).

Cost

The cost of treated water emerged as a motive among respondents in the two villages that charged a fee for treated water. The USEPA's affordability criteria suggest that ability to pay becomes strained once the cost of water exceeds 2.5% of the community's median household income (MHI) (8). To obtain the 30 liters per person per day recommended by the World Health Organization to satisfy the basic human needs for drinking, cooking, and personal washing (9) in the two villages that charged for treated water, residents would be required to pay more than the USEPA affordability standard, at 2.99% and 3.39% of MHI [$0.0263 per L x 30 L per day x 365 days per year x 3.84 occupants per home (7) / $36,932 MHI (7); $0.0343 per L x 30 L per day x 365 days per year x 4.35 occupants per home (7) / $48,125 MHI (7)]. There is an additional cost to households in time and fuel to haul the water. When considered in combination with participants' statements about their inability to pay, there is evidence that for some residents with limited economic means, drinking untreated water is not a choice, but a necessity.

Discussion

Understanding why Alaska Native people continue to drink untreated water when treated water is available is essential to designing effective and culturally responsive behavior change strategies toward waterborne disease prevention. In this study, we explored motivations for drinking untreated water in four Southwest Alaska Native village communities that had access to treated water via a self-haul water system.

Qualitative analysis of data revealed the six motivation themes for drinking untreated water: Chemicals, Taste, Health, Access to Water, Tradition, and Cost. Among those six motivations, Chemicals, Taste, and Health stood out in terms of the frequency at which they were reported; together, they accounted for 117 of the 204 (57%) statements provided by respondents, and those who cited one of them often cited the others. Further, these three motivation themes were related to the presence of chlorine in treated water. Most respondents who mentioned Taste as a motivation focused on their dislike of chlorine, while respondents who mentioned Health were concerned about the safety of chlorine in treated water. These concerns about Chemicals, Taste, and Health are similar to those reported in a study conducted in Northwest Alaska (6) as well as in studies conducted with non-Alaskan populations (10-13).

The motives described by participants in this study highlight the relationship between individuals and their environments (social, built, and policy). These findings attest to the need for strategies that respond to issues and concerns occurring at multiple levels of the social-ecological framework. Public health interventions that take a social-ecological approach are particularly relevant to the environmental health profession because this approach acknowledges the importance of the environment in shaping individual behavior (14). The three supra-individual levels of the social-ecological framework (family, community and policy) are directly applicable to at least three different kinds of environments (social, built and policy), as will be illustrated below.

Structural modifications to the built environment, such as providing houses with piped water service, are often beyond the capacity of public health interventions. Nevertheless, such strategies fall within the scope of environmental health practice. Social-ecology provides a framework for taking full advantage of the unique capacity held within the environmental health profession. Here, we use the social-ecological framework to suggest intervention strategies that are specific to the findings from this research and possibly transferrable to other populations, settings, and topics. Specifically, we discuss recommendations for the individual and the social, built, and policy environments. The individual and the social, built, and policy environments were deemed relevant to the study because our data suggested that they were areas where interventions could bring about the desired changes in behavior.

Individual Level

In our study, personal factors such as knowledge, attitudes, beliefs, and perceived barriers influenced residents' decisions to drink either treated or untreated water. For example, respondents expressed their concern about the taste and health consequences associated with chlorine (motive themes: Chemical, Taste, Health). A strategy for addressing this concern would be to develop an education campaign. While health promotion materials may be available, it is important that the processes and materials of the campaign are adapted and contextually tailored to the specific circumstances, culture, and setting of the target population (15).

Social Environment

The social environment includes the individual's family, community, culture, and social norms. In this study, respondents described drinking untreated water as a long-standing traditional practice (motive theme Tradition). Activities to intervene must honor traditional practices while bringing forth new evidence-based health information. One strategy is to use participatory methods, such as those suggested by Fisher and Ball (16), where respected Elders and others are invited to be involved in all phases of community-level intervention, including development, implementation and evaluation; this would help to ensure community acceptance, cultural sensitivity, and credible avenues of information diffusion (such as through community presentations, school classroom projects, and water treatment facility tours) (16).

Built Environment

The physical environment comprises surroundings that are natural and built. Together they provide the setting for water source decision-making and opportunities for intervention. In our study, participants reported limited access to treated water (motive theme: Access). In the case of these four communities, this could be addressed by constructing piped water distribution systems that provide a convenient and plentiful supply of treated water to the home. Modifying the built environment offers the best solution for those who drink untreated water due to physical- or age-related disabilities and live in communities where construction a piped water system is feasible. Marino et al. (6) observed that residents with piped water service were more likely to drink treated

water than those who self-hauled water. This was true even though both groups preferred untreated sources. Unfortunately, piped water systems may not be constructed in every community due to engineering and economic limitations. Environmental health practitioners are uniquely positioned to collaborate with colleagues from other disciplines to develop alternatives to piped water systems. In fact, at the time of this report, the State of Alaska has called for the formation of multidisciplinary teams that pair EH professionals with experts from other fields such as engineering, health education and economics to come up with innovative alternatives (http://watersewerchallenge.alaska.gov/).

Policy Environment

The policy environment includes legislative, regulatory, policy-making, and ordinance actions that affect water source decisions. The policies most relevant are those that determine the fees that grant residents access to treated water, along with the payment structures developed to cover these fees. Two common methods of charging for water include metered rates and flat rates. With metered rate structures, households pay for water on a per-unit basis. With flat rate structures, households pay a set monthly fee for unlimited water use. Metered rate structures are widely used to promote water conservation while flat rate structures promote liberal use (17). As long as paying for water poses a continuing challenge for residents in these economically limited village communities, flat rate structures should be adopted to address the motive theme of Cost.

Revising the payment systems to incentivize consumption of treated water is important and possible.

These recommendations are provided to inform the design and implementation of a behavior change program to reduce consumption of untreated water in these four village communities. The recommendations are based on a social ecological framework and sound principles and longstanding standards of environmental health practice. There are some limitations that should be considered. Because we did not audio record the surveys, data are subject to the recollections and potential bias of surveyors. In addition, because data were collected from only one representative of each household, their responses may reflect only their specific activities or beliefs and may not accurately portray those of the other household members.

Conclusion

Consuming untreated water is a universally recognized risk factor for infectious disease. As such, strategies for encouraging and supporting consumption of only treated water are critical. This study found that 82% of surveyed households were drinking at least some untreated water even though treated water was available in their community. Interventions addressing the motives described by respondents have the potential to decrease the use of untreated water and increase the use of treated water in these villages. While our findings are specific to a unique population and setting, they corroborate those from studies conducted in other regions of Alaska and outside of Alaska.

While this paper reported on the motives causing residents of four small, predominantly Alaska Native communities to consume treated or untreated water, we suggest that usefulness of this research extends beyond the topic, population, and setting in two ways. First, we use qualitative data collection and analysis, an approach that is underutilized in the field of environmental health. In fact, a review of 3,155 articles published between 1991 and 2008 found that even though qualitative data are rarely published in traditional environmental health journals, nearly all studies that did include these data reported increased scientific understanding (18). Environmental health professionals may want to consider a qualitative approach as presented here in designing their future targeted intervention strategies. Second, our recommendations for behavior change are based on a social ecological framework, a framework that we suggest has particular applicability within the environmental health profession because of how it acknowledges and applies the role of the environment in shaping individual behavior. While we provide recommendations to address the risks associated with consuming untreated water, the social-ecological model could be applied to a range of topics in environmental health, such as encouraging food service workers to wash hands, promoting seatbelt usage among drivers, and increasing compliance with environmental regulations, or any issue that acknowledges the important role of multiple environments on human behavior.

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Chapter 3: Alaska Native Consumers Show Increased Treated Drinking Water Consumption Following Project Meq-Egtaq[1]

Abstract

Consuming untreated water is a universally recognized risk factor for diarrheal disease. A recent informative qualitative study found that 82% of households in four Alaska Native village communities were consuming untreated water despite their access to treated water from a central distribution point. Primary reasons described for consuming untreated water included concerns about chemicals and their impact on health, unpleasant taste, inconvenient access to treated water, tradition of collecting water from natural sources, and costs incurred for treated water. In response, a health promotion intervention referred to as Project Meq-Egtaq ('nice water' in local Yupik) was developed and conducted to encourage treated water consumption in households in the same four communities. Project Meq-Egtaq's design was based on findings gl[2]eaned from the aforementioned study during which viable avenues for social-ecological change at the individual and environmental (social, built, and policy) levels were identified. For analysis, households were grouped according to three water delivery scenarios that corresponded to when (or if) they were provided water via self-haul from a central water source or an in-home piped system. Self-reported survey data revealed that from pre- to post-intervention, the proportion of households drinking mostly treated water increased by 21% (39% to 60%), $p < 0.0001$. Similar findings were found regardless of water

[1] Ritter, T.L., Lopez, E.D.S., K. Hickel, Dobson, J., Smith, J., Johnson, R.M., & Bersamin, A. (In preparation). Alaska Native consumers show increased treated drinking water consumption following project meq-egtaq. Journal of Environmental Health.

[2]

delivery scenario. Our findings suggest that in conjunction with providing access to treated water sources (self-haul and piped in-home), offering health promotion interventions has the potential to improve healthful water consumption behaviors in Alaska.

Introduction

Diarrhea is the second leading cause of child death worldwide (1) and much of the disease burden can be attributed to untreated water consumption (2, 3). Water treatment is a process by which pathogens are removed from the water supply to protect against diarrheal disease. Common water treatment processes include adding chlorine to destroy pathogens and performing filtration to physically remove them.

Nearly all Alaska residents currently have access to treated drinking water but the method by which treated water is transported between the water treatment plant and the consumers' home differs. Three methods for water delivery commonly used in Alaska include self-haul, vehicle haul, and in-house piped water. Only self-haul and piped water methods are relevant to this report. The self-haul method requires residents to haul treated water from a water distribution water point to their home. These households must also dispose of sewage using a five-gallon bucket (often referred to as a "honey bucket") with a toilet lid. The piped water distribution method provides direct access from the treatment plant to the home via internal pressurized fixtures. Households with piped water also have modern flush toilets for sewage disposal.

Availability of water and sanitation infrastructure will not provide a health benefit unless the population adapts to the technology (4). Regardless of their water distribution method, many Alaska residents report consuming water from untreated supplies and sources. A recent informative qualitative study conducted in four Alaska Native village communities in Southwest Alaska found that 82% of households reported drinking untreated rain and river water even though treated water could be self-hauled from the water point (5). Reasons given for consuming untreated water included concerns about chemicals and their impact on health, unpleasant taste, inconvenient access to treated water, long-standing traditions of using water collected from natural sources, and costs incurred for purchasing treated water.

Health promotion is the art and science of helping people change their lifestyle toward a state of optimum health (6). Health promotion interventions have proven to be successful in encouraging healthy water use behaviors with non-Alaskan populations (7) but their specific application to treated water use in Alaska has not been tested (8).

The health promotion project was given the name Meq-Egtaq (pronounced muk-ekk-tak) by a local resident. Meq-Egtaq means “nice water” in the local Yup’ik language. Project Meq-Egtaq is described as a health promotion behavior change intervention designed to encourage treated water consumption and the pre-post evaluation designed to assess its impact. This study examined households from the same four Alaska Native village communities that were previously identified by Ritter et al. (5). Each participating household had one of three water delivery scenarios: 1) self-haul only: households with

self-haul water delivery at pre- and post-intervention; 2) self-haul to piped: households with self-haul water delivery at pre-intervention, but transitioned to piped water distribution during the project period; or 3) piped only: households with piped water distribution at pre- and post-intervention. It was hypothesized that regardless of water delivery scenario, Project Meq-Egtaq would result in a significant increase in the proportion of households that report consuming treated water. It was also hypothesized that households in the self-haul to piped water group would report the largest decrease in untreated water consumption because the barrier of access would be addressed by providing in-house running water.

Methods

Program of Research

The study to examine the impact of Project Meq-Egtaq on treated water consumption was one of several components that comprised a larger program of research titled the *Impact of In-home Water Service on the Rates of Infectious Diseases*. The aim of the program of research was to better understand how providing modern sanitation services (piped water and flush toilets) would affect water use, domestic hygiene practices, and rates of infectious diseases among residents of four Alaska villages where most homes were scheduled to receive piped modern sanitation services during the course of the study. One aspect of this larger study was to explore avenues for encouraging healthy water use practices.

Ethics

Study materials and procedures were approved by the Alaska Area Institutional Review Board, the Human Subjects Review Committee of the regional tribal health organization, and the four representative village councils.

Participant Eligibility and Recruitment

All households in the four village communities were invited to participate in the health promotion activities offered through Project Meq-Egtaq as well as the pre- and post-intervention surveys. Recruitment methods included announcements made over VHF radio (a simple transmitting device used as a primary method of communication in this region), informational flyers, and household visits by project staff.

Pre-Intervention

Prior to Project Meq-Egtaq, a baseline survey and formative assessment activities were conducted. The baseline survey was conducted to determine the proportion of households consuming untreated water before the program to confirm the need for health promotion. This data was later used as a baseline measure when assessing the effectiveness of Project Meq-Egtaq through pre-post comparison. The surveys were administered in-person by a research team member assisted by a paid resident field worker between October 2007 and November 2008. Households were asked to delegate one person to provide the information. Household representatives (n=220) were asked to report how much of their household's drinking water came from the treated water point

by responding with “none”, “some”, “most”, and “all”. Participants who chose responses other than “all” were asked to elaborate by explaining their motives for consuming untreated drinking water. Interview responses (both closed- and open-ended) were transcribed into an Excel spreadsheet. Quantitative data were analyzed by an Excel formula while qualitative data were analyzed by two members of the research team using a four-phased, grounded-theory process. The qualitative methods are described in greater detail in our previous report on why some people with access to treated water consume untreated water (5).

The vast majority, 82% of households, reported obtaining at least some of their drinking water from an untreated source, indicating a need for a health promotion intervention.

In addition to the surveys, two types of formative assessment activities were conducted and focused on determining the who, what, where, when, why, and how of Project Meq-Egtaq. One activity was to ask the respondents who indicated that at least some of their drinking water came from untreated sources (n=172) to explain their motive(s) for consuming untreated water. For example, some participants conveyed that they consume untreated water instead of treated water because untreated water tastes good and treated water tastes bad (Table 3.1). A second formative assessment activity involved informal discussions with respondents and families while administering the survey. Often, administration of the survey led to a broader discussion that provided additional insight to the topic and on how to effectively intervene. Highlights from these

"kitchen table" discussions were often recorded in the researcher's field notes. As detailed in Table 3.1, we learned that dual messages (such as treated water is safe and healthy *and* untreated water is unsafe and unhealthy) are more persuasive than a single message, the matriarch typically makes the water source decisions for the household, and people prefer to receive health promotion information through in-person discussions that take place in their homes (Table 3.1).

Table 3.1: Findings from the Formative Assessment Used To Inform the Intervention

Area	Findings
Drinking untreated water (Established Need)	• 82% of baseline survey respondents reported some of their household's drinking water came from an untreated source (61% reported most of their water was untreated)
Motivations for drinking untreated water (Why)	• Chemicals: General concerns related to chemicals used in the water treatment process • Taste: Treated water tastes bad/untreated water tastes good. • Access: Treated water is difficult to carry • Tradition: "That's what we've always done." • Cost: Some people don't have money to purchase treated water/untreated water is free
Health Promotion messages (What)	• Drinking treated water is safe and healthy • Drinking untreated water is unsafe and unhealthy
Target groups (Who)	• Household matriarch • New or expectant mothers • 6-8th grade school children • Respected elders
Motivation for change (Why, How)	• "Disgust" associated with drinking sewage-contaminated untreated water • Keeping babies and small children healthy
Channels of communication (How, Where)	• In-house "kitchen table" conversations (primary) • Community gatherings (secondary)

Project Meq-Egtaq

Health promotion activities were carried out in three of the four communities between March 2008 and July 2010, while activities in the fourth community were carried out between November 2008 and July 2010. The health promotion objective was to increase the proportion of households reporting that most of their drinking water came from a treated source. Health promotion programs should be based on theory (9). As such, our activities were based on a social ecological model with four levels of influence: the individual, social, built, and policy environments (10). In Table 3.2, the major activities are described and arranged according to the social ecological level they were designed to influence.

Project Meq-Egtaq was designed to be flexible, offering a "toolbox" of activities that could be tailored to each community's needs and preferences As such, households received varying aspects of the health promotion program. For example, only households with piped water received the items in the Safe Water Use Orientation Kit that pertained to use of pressurized water in the home (bath tub toys, plungers, shower curtains).

Project Meq-Egtaq activities were carried out in partnership with each community using a participatory approach similar to that suggested by Fisher & Ball (11). Respected elders, community leaders, treatment plant operators, field workers, and other key stakeholders were invited to be involved in all phases of the program as a means to help ensure community acceptance, cultural sensitivity, and credible avenues of information diffusion such as community presentations, school classroom projects, and water

treatment facility tours (11). Community and elder engagement was particularly important for addressing the long-standing traditional practice of collecting (untreated) water from natural sources. Their involvement helped to ensure that intervention activities honored traditional practices while bringing forth new evidence-based health information.

We augmented community involvement and capacity by hiring local resident field workers to assist with all phases of the project, including project design, data collection, intervention, and data interpretation. Field workers (three of whom were elders) were appointed by the leadership of each community. One field worker was employed in three of the communities and two field workers were employed in one community. Training was provided per an instruction manual that was created specifically for this intervention study, along with continued mentoring (via monthly phone calls and periodic site visits) throughout the project.

Table 3.2: Project Meq-Egtaq: Tool Box of Activities by Social Ecological Level

Level	Health Promotion Activities

Individual	• Home visits by research team and/or trained field workers:
	  o "Kitchen table" conversations
	  o Distribution of leaflets, flyers, refrigerator magnets
	• Homeowner's Guide for Safe Water Use
	• Safe water use orientation kit[1]

Social Environment	• Involving respected Elders in all phases of the project[2]
	  o Advised program design
	  o Led some intervention activities
	• Microbiological testing treated and untreated water supplies
	  o Performed by trusted community residents/Elders
	  o Results explained by trained field workers/Elders[3]
	• Community activities
	  o Town hall presentations
	  o School classroom demonstrations/projects
	  o Water treatment facility tours
	  o Baby Showers[4]

Built Environment	• Installing modern sanitation services[5] • Training/education for water system operators to ensure proper addition of chlorine • Advocating local stores to stock soap, bleach and detergent
Policy Environment	• Advocating for flat rate cost structure instead of metered rate cost structure [6]

[1]Kits included bath tub toys for kids, children's books, toilet plungers, soaps and laundry detergent

[2]Three of the five trained field workers were Elders

[3]Test results were explained during home visits

[4]Health promotion activities modeled after Western baby showers where members of the research team and field workers gathered with new and expectant mothers (and anyone else who wanted to attend) to discuss healthy water use practices.

[5]59 houses had modern sanitation services at pre-intervention. These houses are referred to later in this report as Piped Only; 108 houses received modern sanitation services in the time period between the pre- and post-surveys. These houses are referred to later in this report as Self-haul to Piped; approximately 83 houses lacked modern services at pre- and post. These houses are referred to later in this report as Self-haul only.

[6]Three of the four communities adopted flat rate cost structures. Flat rate structures are known to encourage liberal water use (12).

Post-Intervention Survey

A post-intervention survey was conducted during a one-week period in August 2010. Household representatives were asked how much of their household's drinking water came from the treated source within the last two months. For each household, the term "treated source" was modified to include the available treated sources, that is, the community water distribution point or the faucet available to that household.

Statistical Methods

Analysis of pre-post data for each of the groups (based on their water delivery scenario) was conducted to determine the effectiveness of Project Meq-Egtaq. The outcome measure of interest was the percentage of households reporting that they "mostly" drink water from a treated source. Chi square (χ^2) tests were calculated to compare the proportion of households mostly drinking treated water by water delivery scenario. The percentage of households (across the four communities) that reported consuming mostly treated water within each group was compared before and after Project Meq-Egtaq. We compared the proportion among all households participating in the survey regardless of whether they had participated in the survey before or after, or in both time points. We also compared the proportion in a subset of households who participated at both time points. The two sample binomial test was used to compare the proportion among all households. We compared the proportion for each of the three water service groups and then for all groups combined.

Results

Pre-Post Survey Results

When households across the three water scenario groups were combined, the proportion of households drinking mostly treated water increased from 39% (85/220) to 60% (111/184), $p < 0.0001$ (Table 3.2). However, the change in households reporting drinking mostly treated water differed by water delivery group. Households transitioning from self-haul to piped water had an increase in the proportion mostly drinking treated water from 59% to 82% ($p = 0.01$) while those with piped water pre- and post-intervention had the largest increase from 19% to 66% ($p < 0.0001$, Table 3.2). Those on a self-haul system pre- and post-intervention showed progress in the proportion of households reporting that they mostly drank treated water but the increase was not significant (19% to 25%, $p = 0.48$). Post-intervention, households with self-haul continued to report a lower percentage of drinking mostly treated water than the other two groups (who had piped water post-intervention).

Table 3.3: The Proportion of Households Reporting That Most of Their Drinking Water Comes from a Treated Water Source Pre- and Post-Project Meq-Egtaq, all Households

Water Delivery Scenario	Proportion Mostly Drinking Treated Water (All Households)		Absolute Change	P-value
	Pre-	Post-		
Self-Haul Only	19% (11/58)	25% (13/53)	+6%	0.48
Self-Haul to Piped	59% (64/108)	82% (59/72)	+23%	0.01
Piped Only	19% (10/54)	66% (39/59)	+47%	<0.0001
All	39% (85/220)	60% (111/184)	+21%	<0.0001

Differences in the numbers involved in pre-and -post intervention reflect outmigration resulting in a reduced number of occupied households post-intervention.

Table 3.4: The Proportion of Households Reporting That Most of Their Drinking Water Comes from a Treated Water Source Pre- and Post-Project Meq-Egtaq, Households Participating at both Time Points

Water Delivery Scenario	Proportion Mostly Drinking Treated Water (Households participating at both time points)		Absolute Change	P-value
	Pre-	Post-		
Self-Haul Only	21% (10/48)	19% (9/48)	-2%	0.70
Self-Haul to Piped	61% (42/69)	81% (56/69)	+20%	0.002
Piped Only	20% (9/46)	59% (27/46)	+39%	0.0002
All	37% (61/163)	56% (92/163)	+19%	<0.0001

Discussion

In the first publication of this three-part series, it was determined that a high proportion of households in four village communities were consuming water from an untreated source. Because consuming untreated water is a risk factor for diarrhea, we developed, implemented, and evaluated a health promotion intervention to help increase the proportion of households reporting that most of their drinking water comes from a treated source. Following the intervention we examined whether households increased the proportion of water coming from a treated source.

It was hypothesized that regardless of water delivery scenario, Project Meq-Egtaq would result in a significant increase in the proportion of households that report

consuming treated water. In support of our hypothesis, when data from all three water delivery scenarios were combined, we observed a significant increase in the proportion of households reporting that “most” of their drinking water comes from the treated source. The results were very similar using data from all participating households (21%; $p < 0.0001$; Table 3.2) and when we restricted the analysis to the subset of households that participated at both time periods (19%; $p < 0.0001$; Table 3.3). Within the 3 groups, there was a significant increase among households that started with self-haul service and transitioned to piped water; and households that started and ended with piped water.

Given that all three water delivery scenarios will continue to exist, health promotion efforts will need to be tailored to each scenario. As some Alaskan communities with self-haul water delivery will not be provided piped systems in the foreseeable future due to cost and engineering constraints, health promotion strategies may be used to maximize the health benefits of their available water infrastructure. Other communities in Alaska are expected to transition from self-haul to piped water in the near future. Our results suggest that health promotion programs can help households adapt to the new technology and increase consumption of treated water regardless of water delivery scenario.

Project Meq-Egtaq was also found to be successful with households that already had piped water service at baseline as many reported consuming untreated water at the time of our pre-intervention survey. Health promotion strategies were developed to address concerns and encourage those who already had piped services to consume the

treated water. We hypothesized that the greatest pre-post intervention increase would occur in households that transitioned from self-haul to piped water during the study period because the new technology would increase access via the changing built environment; some barriers to access would only be addressed among that group. In actuality, this hypothesis was not supported. The greatest absolute increase in treated water consumption was observed among households that started and finished the program with piped water. While the self-haul to piped water group included the highest proportion of households reporting treated water consumption on the post-intervention survey (82%) they also had the highest percentage of households reporting treated water consumption at baseline (59%). As such, there was limited opportunity for improvement.

A possible explanation for the relatively high proportion of households in self-haul to piped water group consuming treated water at pre-intervention is that residents may have received education as part of the water system construction process. While construction efforts were not intentionally meant to include an educational component, as part of their efforts project personnel did offer community presentations, held meetings with community leaders, conducted door-to-door surveys, and often provided information about the benefits of using treated water. These activities took place over a period of about 10 years and involved approximately 15 construction workers and support personnel in each community. Households in the piped-to-piped group might have received similar education when their water system was constructed (approximately three years prior to administering the baseline survey). It is plausible that the messages were forgotten without reinforcement, a phenomenon that has been observed in other health

promotion interventions (13). This suggests that education may need to be on-going to maintain the change in behavior. The lowest absolute increase was observed among households that used a self-haul system throughout the intervention (i.e. did not transition to piped water). This was not particularly surprising as the intervention was initially designed to encourage treated water consumption among households transitioning from self-haul to piped water; the education might not have adequately addressed the issues and concerns related to self-haul water source use, many of which related to access. In addition, households in the Self-Haul Only group did not have the benefit of the informal education provided by workers constructing the piped water system. Future research is warranted to test the impact of tailored health promotion interventions with this group.

Future research is also required to evaluate the specific impact of individual program activities. In an attempt to be flexible, appropriate and responsive, a toolbox of strategies for change at individual and environmental ecological levels was developed. As such, it is unclear which educational strategies and what levels of change were most effective in encouraging water behavior change.

A limitation of this evaluation is the potential of researcher and participant bias. For example, the same individuals who provided some of the health promotion activities also participated in collecting the data used to measure its effectiveness. To limit the potential for bias, data for the post-intervention surveys were collected by teams of two or three people, with at least one non-program person on each team. It is important to note that a companion study, conducted as another component of the larger program of

research, documented that at post-intervention there were reduced rates of diarrhea in self-haul to piped, and piped-to-piped groups, further supporting the validity of our results (ANTHC and CDC Arctic Investigations Program, unpublished data). In addition, because Project Meq-Egtaq was designed to be flexible, all households did not receive exactly the same exposure to health promotion activities. An additional limitation is that because the health promotion activities were designed to work together as a package, we are unable to assess the impact of individual activities.

Conclusion

This report described Project Meq-Egtaq, the first focused long-term attempt to encourage treated water consumption through a formal health promotion intervention in Alaska. We described both the program's design and impact, and demonstrated a 21% overall increase in reported treated water consumption across three water source scenarios: households with only self-haul water delivery that will not be served by piped systems in the foreseeable future, households with only self-haul water delivery that transition to piped systems, and households that already have piped water. Environmental health programs may build on this work to collaborate with their stakeholders to develop effective programming that addresses the situation and water scenarios that exist for the populations they serve.

This paper is one of a three-part series. The first paper in this series called for broader utilization of the health promotion interventions based on a social ecological framework, in shaping water use behaviors. The findings reported here, in the second

paper of the series, further support this recommendation by illustrating how behavior was shaped not only by available water delivery method, but also by education and other social ecological activities. Of concern is that health promotion interventions in environmental health are often informal and lack a theoretical basis. As such, historically, the vast majority failed to show an increase in the target behavior (14, 15). A result is that environmental health professionals may avoid health promotion interventions assuming they will have limited impact. A broader conclusion for the profession is that carefully constructed health promotion programs that are based on theory, obtain formative information about the target population, and include rigorous evaluation are proving to be effective.

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Chapter 4: Alaska Native Consumers of Modern Sanitation Services Provide Insights to Inform Infrastructure Designs and Health Promotion Planning[1]

Abstract

Acute respiratory infections (ARIs), diarrhea, and skin infections are diseases of public health significance in Alaska. Installation of modern sanitation services, such as pressurized running water piped to the home and flush toilets, is a common preventative strategy. While previous research has documented lower rates of disease among residents with modern services, it is not known if and to what degree residents recognize the health benefits. In-person surveys were conducted with residents of four Alaska Native communities who had recently received modern services. Most participants (n=101; 74%) reported improved community health. A prominent theme among participants who reported improved health was that better convenience and access to water resulted in an increase in the volume of water used. Participants further explained how installation of modern sanitation services increased their ability to perform six healthy water use practices known to prevent disease. Our findings suggest that the health benefits of modern services are recognized by consumers. We recommend providing modern sanitation services where possible and augmenting provision of infrastructure with education to encourage healthy water use. New water system designs for communities that cannot support modern infrastructure should prioritize making the water supply convenient and plentiful to encourage healthy practices.

[1] Ritter, T., Lopez, E.., K. Hickel, Dobson, J., Smith, J., Johnson, R., & Bersamin, A. (In preparation). Alaska Native consumers of modern sanitation services provide insights to inform infrastructure designs and health promotion planning. Journal of Environmental Health.

Introduction

Acute respiratory infections (ARIs), diarrhea, and skin infections are diseases of high public health significance. In fact, acute respiratory infections and diarrhea are the leading causes of childhood morbidity and mortality worldwide (1) and community acquired skin infections are an emerging threat (2, 3). Installation of modern sanitation services, such as pressurized running water piped to the home and flush toilets, is a common preventative strategy because availability of the infrastructure facilitates six healthy water use practices that are known to prevent one or more of these diseases. These six practices are hand washing, bathing, cleaning household surfaces (including washing dishes), washing and drying laundry, drinking treated water (instead of untreated river water or rain) and disposing sewage in a safe manner (4-10).

Acute respiratory infections, diarrhea and skin infections are long-standing health challenges for rural Alaska Native populations. In response, Alaskan programs have been working to install modern sanitation services in Alaska Native village communities since 1960. To date, about 80% of rural Alaska Native homes have been provided these services (ANTHC internal data). Residents of about 4,500 to 6,500 homes lacking modern sanitation services self-haul water from a centralized water point and dispose of sewage using a five-gallon bucket with a toilet lid known as a honeybucket (11). The effort has been successful and multiple studies have reported lower rates of infections among residents with modern sanitation services (12-14).

While previous studies using medical records data have established the health benefits of modern sanitation services, prior to the study reported here it was not known if residents actually recognize or understand these benefits. In addition, there are also gaps in the literature regarding how rural Alaskans use water and how health promotion may be used to encourage healthy water use choices. Anticipating that four Alaska Native communities were going to receive modern sanitation services, we set up a series of efforts to fill these gaps in the literature. First, before most homes had modern sanitation services, we determined why residents consumed untreated water when treated water was available from a water point (15). Second, we designed, implemented, and evaluated a health promotion program to encourage consumption of treated water (16). Third, we reviewed electronic medical records to determine if rates of acute respiratory infections, diarrhea, and skin infections declined following provision of modern sanitation services and health promotion (ANTHC and CDC Arctic Investigations Program, unpublished data). Finally, in this report, we describe consumers' perceptions regarding changes in health following provision of modern sanitation services and health promotion (ANTHC and CDC Arctic Investigations Program, unpublished data).

For communities where modern sanitation services are being provided for the first time, it is especially important to understand community perceptions. If residents do not recognize the benefits of water and sanitation services, it may delay or prevent adaptation and performance of the six healthy water use practices. In fact, previous studies in Alaska suggest that adaptation is a problem as consumers often continue to ration water and use untreated rather than treated water even after modern sanitation services have become

available (15,17, 18). As such, our objective was to determine to what degree consumers recognized the health benefits of water and sanitation services. A second related objective was to determine the participants' perceptions of the health impacts resulting from water and sanitation service provision.

Methods

Setting

This research was conducted in four remote Alaska village communities where most households received modern sanitation services between July 2005 and April 2010.

Health Promotion

Health promotion activities were offered to help residents adapt to the new water and sanitation infrastructure and services (16). The health promotion intervention, named Project Meq-Egtaq ("nice water" in the local Yup'ik language), was the first of its kind in Alaska and considered a first step in developing health promotion programming to encourage healthy water use practices. Project Meq-Egtaq's design was based on findings gleaned from an informative qualitative study during which viable avenues for social-ecological change at the individual and environmental (social, build, and policy) levels were identified (15).

Sample

Households were eligible to participate in this study if they were occupied by one or more people and had received modern sanitation services between July 2005 and April 2010, and the services were operational at the time of our visit.

Data Collection

A survey was conducted during a one-week period in August 2010 and each participating household was asked to select an adult to provide the information collected. The survey included questions pertaining to topics of health and water use. Respondents were asked whether or not they felt the health of their community had changed since the piped water and flush toilets were installed. Those participants who indicated that they felt their community's health had changed were then asked to describe the changes they had observed to identify the direction of the change in relation to improved or declining health. Because little is known about the perception of how installation of modern sanitation services leads to better health in Alaska, respondents reporting that health had improved were asked to describe what they thought had caused this change (such as water use practices).

Ethical Approval

The research ethics committees of the Indian Health Service (IHS), U.S. Centers for Disease Control and Prevention (CDC), and the regional tribal health organizations

approved this study. Participants provided written consent prior to their participation in the study.

Data Management and Analysis

All open-ended responses were recorded onto a paper survey form and then transcribed verbatim into an Excel spreadsheet by a professional transcriptionist. The qualitative data were analyzed by two researchers using the five-step directed content analysis process suggested by Taylor-Powell and Renner (19). In step one, the researchers (TR and KH) independently read through each response. During the second step, the researchers established goals for the analysis and identified the following four domains of interest: 1) whether or not the health of the community changed after the provision of modern sanitation services 2) the direction of change in the community's health (in which the direction of the change was noted as better, worse, or could not determine as interpolated by the researchers) 3) the health outcomes that were affected (including diarrhea, skin, respiratory, and other health problems) and 4) how availability of modern sanitation services (including those that allowed hand washing, bathing, washing laundry, and more) affected the perception of change in health. For all four questions, preset categories were used. In the third step, the data from the questions were sorted and categorized. During the fourth step, the researchers reviewed the data for patterns and connections within and between categories. The fifth and final analytical step required the researchers to interpret the data to determine the overall meaning and significance of the findings.

To conclude their analyses, the researchers performed an additional step not included within the process specified by Taylor-Powell and Renner (19) and in doing so, compared their results from steps three to five. Where important differences were identified, the researchers discussed their rationale and came to a mutual agreement.

Results

Reported Changes in Community Health

Of the estimated 359 total households in the four communities, 241 transitioned to modern sanitation services. Of the 241 served households, 41 were not functional at the time of our survey, leaving 200 eligible households. Of these, 137 participated in the survey for a response rate of 69%.

Most participants (101/137) reported they believed their community's health had improved since installation of modern sanitation services (Table 4.1). Thirty-six respondents did not notice an improvement in health and stated that they were incapable of commenting on community health (as opposed to their own health) or attributed the lack of improvement to unserved homes in their community that were preventing residents of served homes from realizing the health benefits. As previously mentioned, not all households were provided modern sanitation services. Some described how they believed sewage contamination originating from these households put their health at risk. One participant stated, "I wish everyone would have piped water. It's not safe having honeybuckets outside for my kids to step on." Only one respondent reported worse health and attributed it to increased exposure to chlorine in treated water, stating, "My daughter

gets little bumps when she takes a bath from the water. [Treated water has] too much chlorine."

Table 4.1: Reported Change in Health Following Provision of Modern Sanitation Services and Education, 2010, Alaska

Change In Health (Number and Percent of Households Reporting Direction of Change)	Illustrative Participant Responses
Better health (n=101/137; 73.7%)	"Less people get sick" "In our house it has less sickness" "Mine and my family's health has gotten better."
No change or don't know (n=35/137; 25.5%)	"Not really because of the flies around. Whenever they're dumping honey buckets [occupants of homes without modern services] they spill on the road." "You'd have to ask the clinic folk." "I don't see no difference. My kids still get sick."
Worse health (n= 1/137; 0.7%)	"My daughter gets little bumps when she takes a bath from the water. Her skin gets dry. Too much chlorine."

About one-fourth (26/101) of respondents who reported better health attributed the improvement to a decreased occurrence of a specific infectious disease. Interestingly, all 26 of these respondents attributed better health to reduced occurrence of respiratory infections, diarrhea, and skin infections. Illustrative comments are provided in Table 4.1. Several of these participants specifically mentioned "kids" or "children" as the group who experienced better health, even though they were not asked to comment on any particular population or sub-group.

Table 4.2: Diseases Affected by Installation of Modern Sanitation Services as Self-Reported by Household Representatives, 2010, Alaska

Disease (Number and percent of households reporting health outcome)	Illustrative Participant Responses
Skin (n=13/26; 50%)	"My son doesn't get the boils he used to get before the running water." "My son hasn't been in the hospital since we moved [to a home with piped services]. He used to get MRSA easily." "Less impetigo." "Having a bath helped some of the kids with sores on their faces."
Respiratory (n=11/26; 42.3%)	"I hardly get any colds. I used to but not since the piped water came." "Less respiratory problems. Less RSVs." "Less cold, flu and sore throat."
Diarrhea (n= 6/26; 23.1%)	"Less sickness. People hardly get diarrhea." "Diarrhea has gone down." "Kids get less sick. Less runs."

Some households provided multiple responses. Therefore, percentages do not equal to 100%.

While the focus of our survey was health and the recognized benefits of modern sanitation services, several participants relayed how the introduction of these services improved their lives in ways not directly related to the prevention of an infectious disease. Their statements told of how the general mood and rhythm of the community had improved, and that there was an increased sense of happiness and wellbeing. Some reported having more energy or described people as peppy. Another respondent explained that better health and less disease led them to observe children going to school more often. Others explained that having piped water and flush toilets in their home was more

convenient, made life easier, and eliminated the time, work, and physical effort required to haul water and pack honeybuckets. Several participants described how eliminating honeybuckets improved quality of life. One participant shared, “No more standing over the honey bucket with a clothes pin over your nose.”

Reported Changes in Water Use

Because little is known about how installation of modern sanitation services leads to better health in Alaska, we asked the 101 respondents who reported better health to explain how they perceived installation of modern sanitation services facilitated the improvement. Ninety participants shared their perspectives. A prominent theme among their responses (31/90) was that better convenience and access to water resulted in a general increase in the volume of water used. One participant explained, “We can use as much water as we want.” Participants described three infrastructure-related barriers to adequate water use that were eliminated by the installation of modern sanitation services: 1) the laborious practice of self-hauling water from the water point replaced by piped water to the home; 2) the need to acquire and use tokens for obtaining water at the water point replaced by a modern mail billing system; and 3) the time-consuming and expensive practice of heating water on the stove top before washing and bathing replaced by availability of modern water heaters.

Eighty-two of the respondents who reported better health and provided a comment on water use (82/101) described how installation of modern sanitation services

increased their ability to perform one or more of the six healthy water use behaviors. As shown in Table 4.3, respondents who attributed better health to improved water supply noted that piped water to the home made it more convenient for household surfaces to be cleaned and allowed for more frequent and better quality hand washing. Others reported that having pressurized water in the home allowed for more frequent bathing and clothes laundering than when they had to go to the washeteria, a community facility where residents without in-house fixtures can go to shower and wash clothes. In addition, others stated that they were drinking more treated water as opposed to untreated rain and river water. Most of those who attributed better health to safer sewage disposal provided comments pertaining to reduced exposure to human waste resulting from elimination of honeybuckets.

Table 4.3: Reported Behavior Changes Associated with Better Health, 2010, Alaska

Model healthy water use practice (Number/percent of households)	Illustrative Participant Responses
Safer Sewage Disposal (n= 31/82; 37.8%)	"When they are carrying honeybuckets they always spill on the sidewalks and [it] makes children sick because they play on the roads." “In the winter a lot of people didn’t haul honeybuckets [to the disposal lagoon] because the snow was so deep so they would overflow and dogs and crows would get into it.” “When I walk around outside I don’t smell [feces] no more”
Hand Washing (n= 30/82; 36.6%)	"[We] wash hands more." "[We] don't have to wash hands in the same water." "My hands feel healthier"
Bathing (n= 27/82; 32.9%)	“Kids are taking baths and showers.” "Having a bath helped some of the kids with sores on their faces." "When our kids come in dirty we just put them in the bath. It's really easy we don't have to heat water for the bath." "[We] don't have to wait for the washeteria to open to shower."
Drinking Treated Water (n= 17/82; 20.7%)	“People are drinking more treated water now.” "Because the water is treated and we have better water for drinking." "When we drank from the river we used to have sickness." "My son's kids hardly get sick and they drink piped water."
Laundry (n= 12/82; 14.6%)	"A lot of people are getting washers. [I] used to wait 2-3 days for the washeteria." "People are able to wash clothes easier." "Clothes are cleaners." "The laundry gets cleaner now."
Household Cleaning (Includes dishes.) (n= 11/82; 13.4%)	"Cleaner house." "Cleaner house. Our family doesn't get sick that often." "People have readily available water to wash hands and dishes." “Our houses are cleaner now that we have the piped water.” “Easier to wash dishes”

Some households provided multiple responses. Therefore, percentages do not equal to 100% (Table 4.3).

Discussion

In this study, consumers who recently received modern sanitation services resoundingly reported that they recognized the health benefits. All participants who provided a detailed comment attributed better health to reduced occurrence of acute respiratory infections, diarrhea, and skin infections -- the same three diseases that a companion study using data from electronic medical records found had significantly declined (ANTHC and CDC Arctic Investigations Program, unpublished data).

While the findings of this study are largely consistent with what was previously known about water, behavior, and health in Alaska, our research adds to the previous body of knowledge in three important ways. One way is that this is the first study of the relationship between modern sanitation services and health in Alaska from the perspective of those who experienced the change. Participants recognized the health benefits, with 74% (101/137) reporting that they observed an improvement in community health. Similar to previous studies based on data from electronic medical records, children were the primary beneficiaries of better health (12, 13, 14). According to our data, further improvements to health and quality of life may be achieved by serving all homes in a community and by developing more effective messaging on the safety and benefits of chlorine in treated water. Some respondents credited elimination of honeybuckets with reduced respiratory infections, even though the association hasn’t been established through published research. Future health promotion messaging should

provide education on the known pathways of respiratory transmission, emphasizing the healthy water use behaviors of hand washing, cleaning environmental surfaces, and laundry for prevention of acute respiratory diseases.

Our study also builds on previous health-related research by being the first to describe the benefits of modern sanitation services in ways unrelated to health. Participants told of having more energy, and living happier, better lives. One participant summarized this sentiment by stating, “Everybody has piped water. It’s like heaven.” Because the focus of our study was to determine if consumers recognized the health benefits of modern water and sanitation, it is possible that important additional benefits were missed. To inform policy decisions, additional research should further explore the topic using methods and questions that are developed to specifically solicit information on the benefits of modern sanitation services that are not related to reduction of infectious disease.

The third way that our study adds to the previous research is that we provide data explaining local perceptions of how installing modern sanitation services can prevent acute respiratory infections, diarrhea, and skin infections. Identification of the specific practices that prevent water-related disease in Alaska is necessary for the development of future interventions to further reduce rates of infectious disease. In the first published paper from Alaska to document better health among residents with modern sanitation services, Hennessy (13) suggested that acute respiratory infections and skin infections are prevented through “hand washing and other personal hygienic measures” brought on by

availability of in-house running water services (13). Our participants' perceptions help to support Hennessy's suppositions. Participants perceived that piped water to the home lead to their increased water use, which, in turn, facilitated their healthy water use behaviors, and ultimately reduced occurrences of acute respiratory infections and skin infections. Respondents associated reductions in diarrhea with drinking treated water (instead of untreated water) and safer sewage disposal, both of which are universally recognized to prevent diarrhea (7).

Studies based on research with non-Alaskan populations have linked increased water use with decreased rates of infections (20). To maximize water use, future water system designs should strive to make water available in the home at a reasonable cost. While our findings reinforce the critical importance of adequate quantities of water, further research is needed to determine if water quantity standards (100 liters/capita/day) based on data from other regions are relevant for Alaska (20).

There are some limitations that should be considered. Project Meq-Egtaq, the health promotion program offered in these four communities to help residents adapt to the provided in-house running water services, informed participants how acute respiratory infections, diarrhea and skin infections can be prevented by liberal water use, healthy water use behaviors, and by drinking only treated water. It is possible that this information influenced participants' responses. In addition, the use of self-reporting surveys limit the study as the validity of the data is dependent on the accuracy of memory and the veracity of each participant. Also, data were collected from only one

representative of each household and their responses may reflect only their specific activities or beliefs and may not accurately portray those of the other adult household members. We used triangulation to increase validity, were data from three additional sources were used to confirm the study findings. In one additional measurement, we used household water meters to confirm the reported increase in treated water use (ANTHC and CDC Arctic Investigations Program, unpublished data). In addition, in one village we measured liquid hand soap consumption over time to confirm that handwashing increased (ANTHC and CDC Arctic Investigations Program, unpublished data). We also reviewed electronic medical records to confirm participant reports of lower rates of acute respiratory infections, diarrhea, and skin infections (ANTHC and CDC Arctic Investigations Program, unpublished data).

Conclusion

In this study, respondents reported that they recognized the health benefits provided by installation of modern sanitation services. Of those reporting better health, many attributed reduced respiratory infections, diarrhea, and skin infections to installation of modern sanitation services. These respondents also described how a more accessible water supply facilitated an increase in healthy water use practices known to prevent acute respiratory infections, diarrhea, and skin infections. This study is consistent with previous studies and adds to the body of literature illustrating the benefits of modern sanitation services in Alaska.

Based on our findings, we suggest providing modern sanitation services where feasible, including the unserved homes found in predominately served communities. Provision of modern sanitation infrastructure should be augmented with education to encourage healthy water use. In addition, education programs should emphasize the safety of chlorine and reasons for its addition to the public water supply. New water system designs for use in communities that cannot support modern piped infrastructure should prioritize making the water supply convenient and plentiful to encourage the six healthy water use practices associated with reduced respiratory infections skin infections and diarrhea. Finally, respiratory infections and diarrhea are leading causes of child death worldwide. As such, interventions to improve child health should prioritize improvements to water supply and sewage disposal.

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Chapter 5: Conclusion

This dissertation describes how water and sanitation infrastructure and water use behaviors come together to influence health. While previous research described the health benefits of modern water and sanitation infrastructure in Alaska (1-3), it did not provide data to illustrate how the health benefits are achieved or the role played by individual behavior. Research from abroad has shown that health benefits of modern sanitation infrastructure are maximized when accompanied by healthy water use behaviors (4-5)

In Chapter 1, the vast majority of participants with access to treated drinking water via a centralized water distribution point (82%; n=172) reported that at least some proportion of their household's drinking water came from an untreated source. Untreated sources included river water and roof-top collected rain. Motives for consuming untreated water were influenced by the built environment, such as lack of piped water to the home, and by consumer perceptions of both treated and untreated water. Chapter 2 described the design and impact of a health promotion program conducted to increase the proportion of households reporting that most of their drinking water comes from a treated source. Participant households included those who received only education and those who received education as well as in-house piped water and flush toilets. Overall, the proportion of households reporting that most of their drinking water comes from a treated source increased from 39% (85/220) to 60% (111/184), $p < 0.0001$. In Chapter 3, participants who received both modern water and sanitation services and education reported improved community health (n=101; 74%). These participants described how having water piped to the home, as opposed to packing water from the water point, led to

increased water use and facilitated the consumption of treated water, hand washing and other domestic hygiene measures known to prevent ARIs, diarrhea, and skin infections (6-12).

There are some recommendations for policy and practice that can be derived from this research. Participants described how lack of modern water and sanitation services made it difficult for them to obtain adequate quantities of water, which encumbered their ability to consume treated water and perform hand washing and other domestic hygiene practices known to prevent ARIs, diarrhea, and skin infections. Based on these findings, I recommend that whenever possible, all rural Alaskan homes should be provided modern water and sanitation services. Because some homes may not be provided modern services due to economic, physical, or other barriers, an alternative water and sanitation system should be developed that will provide adequate quantities of water for consumption and domestic hygiene practices.

Some participants who had access to treated water via a centralized community water distribution point or in-house pipes still continued to consume untreated water. As such, health promotion should be provided to consumers encompassing three water infrastructure scenarios: households with only self-haul water service; households that are transitioning from self-haul service to in-house piped water; and households that that already have in-house piped water. Health promotion activities have been effectively used to help populations adapt to new water and sanitation technologies (13). While the health promotion program resulted in a 21% increase in treated water consumption,

future research should explore avenues for further increasing the effectiveness of health promotion techniques, with the ultimate public health goal of eliminating untreated water consumption.

In summary, this dissertation provides evidence that water and sanitation infrastructure and water use behaviors come together to improve health through reduced rates of ARIs, diarrhea, and skin infections. While previous research from Alaska reported lower rates of these diseases among those with modern sanitation services, it was not known how the health benefits were achieved. Through qualitative inquiry, I demonstrated that increased access to water via in-house piped supplies leads to increased water use and facilitates consuming treated water, hand washing, and other domestic hygiene practices. It was also not known if or to what degree health promotion could be used to encourage healthy water use practices. This research demonstrated that health promotion can lead to increased treated water consumption, both when paired with provision of modern sanitation infrastructure and when used as a stand-alone intervention. This information will be useful for developing new alternative water systems for households that cannot be provided modern piped water and sanitation services and for developing effective health promotion programming to encourage healthy water use practices.

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